

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 1 of 9</b>
Prepared By: Robert Chmiel		Approved By: Andrew Ackerman		Approved By: Joe Levesque

\*Approval signatures on file with master copy.

## Purpose/Scope

The purpose of this assessment is to evaluate the facility related fire protection aspects of Building 729 to ensure compliance with DOE fire protection criteria. DOE fire protection criteria are outlined in DOE Order 420.1. A Fire Hazard Analysis, required for the Safety Analysis Document for this facility, is incorporated in this assessment.

## Summary

The level of fire protection in this building is sufficient to classify this building as an "improved risk", thereby meeting the objectives of DOE Order 420.1. No items exist for which improvement measures are recommended.

## Status of Recommendations

Recommendations from the previous survey:

FHA97-729-1 To the extent possible, the Class 4 laser installation and use in Bldg. 729 should comply with the recommended practices in NFPA 115, Laser Fire Protection.

FHA97-729-2 The oil coolant in the Klystrons should be tested to determine if the oil contains PCBs.

The oil was sampled in 1997, and all Klystrons showed PCB's below minimum detectable levels.

## Analysis

### 1. Construction

Building 729 is a one-story steel framed building with insulated metal panel walls and a standing seam metal roof deck on a poured concrete slab. The total building area is approximately 7600 sq. ft. The building is attached directly to the north side of existing Building 726. Several 8 ft. high concrete shielding walls are located in the north section of Bldg. 729. The configuration of these shielding walls may vary over time based on several proposed experimental setups. Plans reviewed as part of this survey include the current machine configuration. The arrangement of the shielding walls is shown in Figures 1, in Attachment A of this report. The shielding walls house an electron gun and a linear accelerator, as well as laser systems.

At the present time there are no plans to provide a roof over the shielding wall enclosure. The mechanical equipment room in Building 729 is separated from the remainder of the building by one hour rated fire walls. There are no other fire rated interior walls. The control area for the accelerator is located on the general floor area of the building, with no fire separation (see Section 2.2.1 for details). A clean room that houses a Class IV laser system is located in the southeast section of Bldg. 729. The clean room is constructed of a 3 in. thick polystyrene core wall system covered with a vinyl-covered hardboard (combustible construction).

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 2 of 9</b>

### **1.1 Fire Barrier Integrity**

There are no fire barriers required for Building 729. As indicated above, Building 729 is attached and open to Building 726. Therefore, the two buildings are considered to be a single fire area. Potential fire hazards in Building 726 which could affect the operations of the Source Development Laboratory in Building 729 are discussed in the appropriate sections below.

### **2. Occupancy and Associated Fire Hazards**

The occupancy of Building 729 is classified as industrial. The building is occupied by a Source Development Laboratory consisting of an electron gun, a linac, a transport line, and associated related equipment enclosed in concrete shielding walls. The remainder of the building is occupied by various electrical, electronic, and mechanical equipment to provide for operation and control of the Accelerator. There is also a mechanical equipment room located in a separate room in Building 729. Combustible loading within Building 729 is considered light. Automatic sprinkler protection is provided throughout Building 729.

The clean room installed in the southeast section of Bldg. 729 is designed to house a Class 4 laser system. Class 4 lasers are considered to be beam ignition hazards. To the extent possible, the laser installation and use should comply with the recommended practices in NFPA 115, Laser Fire Protection.

The scope of NFPA 318, Protection of Clean Rooms, is for semiconductor facilities containing clean rooms. The clean room in Bldg. 729 is not intended for semiconductor production and therefore was not designed to the requirements of NFPA 318. The clean room in Bldg. 729 was designed and installed as a combustible structure containing high value electronic equipment. There is also a room in the northwest corner of the building which is designed to house a class 4 laser system. The wall separating the accelerator from this laser area is a concrete shield wall, and the wall enclosing the laser area from the rest of the open floor space is aluminum panel with internal aluminum honeycomb constructed walls.

Building 726, which is attached to Building 729, will continue to be used as a light machine shop. The combustible loading in this area is considered to be light to moderate. Automatic sprinkler protection is provided throughout Building 726. There is a herculite curtain installed above the doorway and half height wall between Bldg. 729 and Bldg. 726. This curtain is being used for thermal stability within the Accelerator area of Bldg. 729. The curtain has automatic sprinkler protection located on both sides.

#### **2.1 Critical Process Equipment**

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a credible fire, could delay a significant component of a major program for a period in excess of 6 months.

By the above definition, the Accelerator and the associated equipment in Building 729 are not considered to be critical process equipment.

#### **2.2 Special Occupancies**

Special occupancies include electronic data processing and vital/important records. The special occupancies of Building 729 are expanded upon in sections 2.2.1 and 2.2.2, below.

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 3 of 9</b>

### **2.2.1 Electronic Data Processing**

The control equipment associated with the operation of the Accelerator in Building 729 is to be located on the general floor area of the facility. This arrangement is acceptable since the control room equipment is not considered to be essential as defined by DOE/EP-0108, Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems.

### **2.2.2 Vital and Important Records Storage**

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or extra expense.

Based on the above definition, there are no vital or important records associated with this program.

## **2.3 Unique Fire Hazards**

Unique fire hazards include; modular buildings, trailers, cooling towers, flammable liquid & gas storage, cable trays, housekeeping in vital areas, and highly combustible building materials. The unique fire hazards of Building 729 (and Building 726) are expanded upon in sections 2.3.1 through 2.3.8, below.

### **2.3.1 Modular Buildings**

There are no modular buildings attached directly to Building 729. Modular Building 728, located 30 ft. to the west of Building 729 and Building 726, is not considered to be an exposure hazard (see Section 6 for details).

### **2.3.2 Trailers**

There are no trailers located near Bldg 729 that would create any exposure hazards.

### **2.3.3 Cooling Towers**

There are no cooling towers associated with Building 729. There is a large pad mounted chiller located approximately 10 ft. north of Bldg.. 729. The chiller is constructed of noncombustible materials.

### **2.3.4 Flammable Liquid & Gas Storage**

The amount of flammable liquids stored in Building 729 and that which exists in Building 726 is minimal. Storage is generally restricted to a safety cabinet located at the West end of Building 729. Incidental use and storage outside of the flammable liquid storage cabinet does not exceed the quantities allowed by NFPA 30, Flammable and Combustible Liquids Code. The maximum allowable quantities permitted by the New York State Building Code of flammable liquids stored or in use are not exceeded within Bldg 729.

There are four Klystron/modulator Systems located in Building 729 and plans to add one additional unit in the future. Each system contains approximately 150 gallons of a Class IIIB (FP > 300 deg. F.) combustible oil coolant similar to transformer oil. The systems are provided with secondary containment. The automatic sprinkler protection provided in Building 729 is considered to provide adequate protection for this hazard.

The oil in the four Klystrons was sampled in 1997, and all were found to be below minimum detectable levels.

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 4 of 9</b>

There is no flammable gas cylinder storage at Building 729 or Building 726. The gas cylinder storage area is located outside, adjacent to Bldg. 727, which presents no significant risk to Building 726 or 729.

### **2.3.5 Cable Trays**

High voltage, low voltage, control, and signaling cables are to be segregated in accordance with NEC requirements throughout Building 729. The cabling is located in conduits, raceways and cable trays. In most instances, the cables in the cable trays meet the IEEE 383 flammability test criteria.

Automatic sprinkler protection is provided throughout Building 729, providing adequate protection for the cable trays.

### **2.3.6 Housekeeping in Vital Areas**

Housekeeping in Building 729 is reviewed during quarterly Tier I inspections to assure that conditions are kept adequate to minimize potential fire hazards. Housekeeping in Building 726 is adequate to minimize potential fire hazards. This is also confirmed by quarterly inspections.

### **2.3.7 Highly Combustible Building Materials**

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction at Building 729. The clean room which houses the laser system is constructed of a 3 in. thick polystyrene core wall system covered with a vinyl covered hardboard (combustible construction). The clean room is provided with automatic sprinkler protection.

### **2.3.8 Combustible shielding**

To improve the radiation shielding of beamline components, a polyethylene based material containing 5% boron was installed in various areas. King Plastic Corporation manufactured this basic material for the poly-boron shielding. ThermoReax did the manufacturing of the sheets to the projects specs under purchase order 44000. There was no specific fire test available to assist in the evaluation of the hazard of the 5% Boron polyethylene. The DOE fire protection community was contacted to determine if similar materials were evaluated. Only information on the 30% Boron polyethylene was available. As a result, a conservative assumption has to be that the 5% polyethylene is as combustible as the pure polyethylene.

Polyethylene is a high density plastic. It will burn when exposed to radiant heat flux in excess of 20kW per square meter. The rate at which it will burn is not excessively high. It will not produce a flash fire. It will produce heavy black smoke, as do most plastics. A burning fire will be detected by the conventional smoke detection system installed at the facility. Smoke damage will occur throughout the large expanse of the accelerator building. The ceiling mounted fire sprinkler system will contain and extinguish the fire. The slow burning high density plastic will not increase the fire and smoke damage beyond the \$1 million dollar loss criteria specified by DOE.

## **3. Fire Protection/Suppression Features**

### **3.1 Site Water System**

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and one 350,000 gallon capacity). The wells have electric primary drivers and a

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 5 of 9</b>

limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gpm for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the area of the NSLS Facility has a static supply pressure of 65 psi. The combination domestic and fire water supply system can supply 1,378 gpm at 60 psi (based on test results from a 8/18/97 test). Computer modeling of the site's system, with physical proofing of the model, confirms that this supply is adequate for the automatic sprinkler system in the building.

### **3.2 BNL Fire/Rescue Group**

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, (NFPA) Hazardous Material Technician Level, and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 2700 people. A minimum of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally at least four firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medevac services are available to BNL via the Suffolk County Police Department.

Additionally the Fire/Rescue Group has two 1500 gpm "Class A" Pumpers, a brush truck, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to the SDL Facility is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stony Brook University.

### **3.3 Site Fire Alarm System**

Brookhaven National Laboratory provides central fire alarm station coverage by an Underwriter Laboratory listed multiplexed Site Fire Alarm System. The system complies with the requirements of NFPA 72 for a Style 7D System.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A secondary alarm monitoring system station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm.

### **3.4 SDL Fire Suppression and Detection**

Manual fire alarm pull stations are installed at all egress doors throughout Building 729 and Building 726. Supervised fire alarm bells are located throughout the facility. Duct smoke detectors are provided on the air supply systems located in Building 726 and on both the supply and return air systems located in Building 729. In addition, spot type smoke detectors are located at the ceiling and below the raised floor of the Laser Room located in Bldg. 729.

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 6 of 9</b>

Automatic heat detection is provided for the portable structure located west of Building 729. Automatic sprinkler protection is provided throughout Building 729 including within the Laser Room in the southeast section of the building. This sprinkler system is designed to provide a minimum density of 0.15 gpm over the hydraulically most remote 2600 sq. ft. area. The water demand for this hydraulic design is 447 gpm @ 44 psi at the base of the riser. The water supply in the area of Building 729 is adequate to meet the required demand of this system including 250 gpm for hose streams. Two fire hose connections fed from the sprinkler system are located in Building 729.

Automatic sprinkler protection is also provided throughout Building 726. The sprinkler system is designed on an ordinary hazard pipe schedule system. It is estimated that the system is capable of providing an average density of 0.15 gpm over the hydraulically most remote 2500 sq. ft. area including 250 gpm for hose streams which is required for the existing occupancy. The building fire alarm system is arranged to annunciate: locally, at BNL Fire/Rescue Headquarters (Building 599), and BNL Police Headquarters (Building 50).

An adequate number of properly rated hand-held fire extinguishers are located throughout this facility in compliance with NFPA 10.

The fire protection/suppression features of vital programs, high valued property, and essential safety class systems at Building 729 are expanded upon in sections 3.5 through 3.7, below.

### **3.5 Fire Protection of Vital Programs**

The operation associated with this facility is not considered to be a vital program. Therefore, no special fire protection precautions, beyond those that are described above, are required for this facility. As a general note, the fire protection features presently provided at this facility should prevent a credible fire from delaying this program in excess of six months.

### **3.6 Fire Protection of High Value Property**

The Source Development Laboratory is considered to be high valued property. However, due to the noncombustible building construction, the relatively low combustible loading in the accelerator area, and the overall noncombustible construction of the Accelerator, a maximum possible fire would not be expected to cause 100% loss of the Accelerator. It is estimated that approximately 25% of the Accelerator's value could be lost or damaged in a maximum possible fire. While this value exceeds \$1 million, the fire protection features provided in Building 729 should limit this dollar loss expectancy to an acceptable level (under \$250,000).

### **3.7 Protection of Essential Safety Class Systems**

There are no essential safety class systems associated with this non-nuclear facility.

## **4. Fire Loss Potentials**

Fire loss potentials are classified into three major categories; the maximum credible fire loss, the maximum possible fire loss, and the recovery potential. The loss potentials for Building 729 are expanded upon in sections 4.1 through 4.3, below.

### **4.1 Maximum Credible Fire Loss (MCFL)**

The Maximum Credible Fire Loss (MCFL) for any given area of Building 729 is expected to be less than \$250,000. Typical areas where a loss of this magnitude could be expected to occur include; cable trays in the vicinity of the Accelerator and/or electron gun, electronic control equipment for the accelerator, and oil filled Klystron/modulator Systems on the general floor

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 7 of 9</b>

area. The fire protection features at this facility are sufficient to restrict the estimated MCFL to within acceptable loss limitations specified by DOE.

#### **4.2 Maximum Possible Fire Loss (MPFL)**

The Maximum Possible Fire Loss (MPFL) for this facility is estimated to be the result of an uncontrolled fire in the general building area that would involve the coolant oil in the Klystron/modulator Systems. Assuming a 25% loss and/or damage to the building and a 25% loss and/or damage to the building contents, including the Accelerator and associated equipment and extensive damage to the associated cabling, a loss in excess of \$2 million could be anticipated. The fire protection features presently provided for the facility should prevent a MPFL of this nature from occurring in Building 729. The MPFL for this facility resulting from an uncontrolled fire originating in Building 726 is estimated to be in excess of \$1 million due to the smoke damage potential that could occur to the Accelerator equipment in the Building 729. Again, the fire protection features provided at the facility should prevent a MPFL of this nature from occurring in Building 726 and Building 729.

#### **4.3 Recovery Potential**

It is unforeseeable that a credible fire in Building 729 or Building 726 would result in a shutdown of the Accelerator for an excessive period of time (greater than 6 months).

#### **5. Security Considerations Related to Fire Protection**

The facility is provided with card access controls. They are arranged not to impede egress. There are no security considerations which relate to fire protection at this facility.

#### **6. Exposure Fire Potential**

Exposure fire potential at Building 729 is limited to the possible exposure from Building 727, Building 728, and a 1500 kVA transformer yard. The space separations and other relevant factors of these exposures are discussed below. There are no additional fire exposures beyond those noted above. There is a 20 ft. separation between Building 729 and Building 727. Building 727 is a fully sprinklered metal panel building with light combustible loading. Based on this information, Building 727 is not considered an exposure hazard to Building 729. There is a 30 ft. separation between Building 729 and Building 728. Building 728 is an unsprinklered modular office building of wood construction, having a total floor area of 3600 sq. ft. Based on this information, Building 728 is not considered an exposure hazard to Building 729.

A 1500 kVA oil filled transformer, with adequate containment curbing, is located approximately 50 ft. north of Building 729. Based on Factory Mutual Data Sheet 5-4, the transformer is not considered an exposure hazard to Building 729.

#### **7. Environmental Impact due to a Fire (Including Water Runoff)**

Toxic, biological, and radiation incidents resulting from a fire, including water runoff, could have an impact on the environment. The potential for these incidents occurring at Building 729 are expanded upon in sections 7.1 through 7.3, below.

##### **7.1 Toxic Incident**

There are no known materials in Building 729 that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

##### **7.2 Biological Incident**

Due to the lack of biological matter at this facility, an incident of this type is unforeseeable.

Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 8 of 9</b>

### 7.3 Radiation Incident

No radioactive materials are used or stored in Building 729. By the nature of the operations of the accelerator, various pieces of equipment can be expected to become activated. This activation is not expected to pose a significant environmental impact in the event of a fire.

### 8. Prefire and Emergency Planning

The BNL Fire Department maintains an adequate prefire plan book for this facility. A local emergency plan is maintained by the NSLS department.

#### 8.1 Fire Apparatus Accessibility

Fire apparatus accessibility complies with the New York State Fire Code and is adequate at this facility.

### 9. Life Safety Considerations

Major life safety considerations for this industrial facility include the following components; means of egress components and capacity, number and arrangement of the means of egress, travel distances to exits, discharge from the exits, and emergency lighting and marking of the means of egress. At Building 729, all of the above components are in accordance with the requirements of NFPA 101, The Life Safety Code.

To accommodate the installation of the clean room, an exit door on the east end of Building 729 was permanently removed from service. The removal of this exit door does not affect the facilities compliance with the Life Safety Code.

### 10. Natural Phenomenon Hazard Exposure

Natural Hazards can be classified into five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

#### 10.1 Lightning Potential

Based on NFPA standard 780 a lightning protection system is required. Refer to Appendix A that shows that the expected lightning frequency (Nd) is **0.0017** and the tolerable lightning frequency (Nc) is **0.006**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed. By these criteria, lightning protection is not required for Building 729.

#### 10.2 Windstorm Potential

The Long Island area basic wind speed (3-second gust) is 110 MPH based on Factory Mutual Data Sheet 1-28 and BCNYS Figure 1609.4. The ground roughness exposure category for the area is 'Exposure B.' Based on the calculations this building should have roof assemblies classified as "Class 90" rated assemblies. Construction drawings from the building's manufacturer indicate the windstorm resistance is adequate.

#### 10.3 Wildland Fire Potential

Building 729 was not included in the "*BNL Wildland Fire Interface Survey Report*," dated August 2002.

An analysis was completed consistent with the requirements and guidelines of NFPA 1144 Protection of Life and Property from Wildfire (2002) to determine the wildfire risk to Building 729. The risk assessment was conducted in accordance with the Wildfire Hazard Severity Form checklist of NFPA 1144. The checklist is a summary of typical desirable characteristics found in various wildfire hazards analyses. Elements include emergency response ingress and egress, type of vegetation, topography, building construction and roofing materials, available fire



Brookhaven National Laboratory/ LIGHT SOURCES DIRECTORATE				
<b>Subject:</b>	<b>Building 729 Fire Hazard Assessment/ Fire Hazard Analysis</b>			
<b>Number:</b>	<b>LS-ESH-0065</b>	<b>Revision:</b> 1	<b>Effective:</b> 6/16/09	<b>Page 9 of 9</b>

protection, and utilities.

Based on the analysis, the hazard from wildfire to Building 729 is "Moderate", with 40 being the cut-off for low hazard (a moderate hazard is 40 – 69). Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix B of this report.

#### **10.4 Earthquake Potential**

The seismic damage potential for this facility is classified as low based on a Natural Hazards Analysis produced for the BNL site titled "DOE Accelerator Order 5815.25 Implementation Plan for Brookhaven National Laboratory National Phenomena Hazards Evaluation" dated April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

#### **10.5 Flooding Potential**

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled "DOE Accelerator Order 5815.25 Implementation Plan for Brookhaven National Laboratory National Phenomena Hazards Evaluation."

#### **Appendix A:**



Lightning Protection  
B0729.pdf...

#### **Appendix B:**



2002 Wildland  
Interface Survey Final